inhabitants of the village were in bed. So far as known no one noticed the period of quiet immediately preceding the heavy downfall.

Waterspouts have been observed along both coasts in Panama. It is not known whether such a phenomenon would be likely to occur at night.

Experiments here in pouring water into the raingage funnel gave a record approximately the same as you report. We were not able, however, to count the top and bottom tips, due to the blurred character of the record.

As previously stated, the Porto Bello maximum rainfall record, *although not entirely above suspicion*, was accepted as probably approximately correct. If the blurred portion of the record is *not genuine*, the malicious pouring of a quantity of water into the raingage was thought to be the most plausible explanation.

Porto Bello has experienced some very heavy rains. The rainfall station there was not in operation from August, 1914, to December, 1918, but the following newspaper report of a heavy downpour on the night of May 4–5, 1918, illustrates the excessive character of the rainfall.

"HEAVY RAINFALL IN PORTO BELLO.

"Reports from Porto Bello are to the effect that on the 5th of May (1918), a torrential downpour occurred in that town and vicinity, causing a number of land slips on the adjacent hills and considerable damage to growing crops. All of the creeks overflowed, and the water invaded the streets of the village. Some of the houses in Porto Bello are reported to have been destroyed by the inundation. The new telephone line suffered some damage through the rushing waters having overthrown trees, which fell across the line. It is said that such a rainstorm as the village just experienced is the greatest within the memory of the oldest inhabitant. No lives were lost."—(*Star* and *Herald*.)

Respectfully,

H. G. CORNTHWAITE,
Assistant Chief Hydrographer.

DISCUSSION.[2]

There was considerable discussion of this paper. J. Warren Smith told of how, in a cloudburst in Ohio, in which 7 inches of rain fell in half an hour, people who were out in it said that they were almost drowned and had to hold their hands over their faces to get air. S. P. Fergusson asked if there could be such rapid condensation in the atmosphere. C. F. Brooks thought that the 17-minute period of slack rainfall preceding the cloudburst was a necessary accompaniment to such an excessive rainfall, for the rate of rainfall much greater than any possible rate of condensation indicated that there must have been strong upward currents holding the raindrops up in the air, and that therefore there must have been downward current and little rainfall about the region of up-rush. H. C. Hunter called attention to the rainfall at Guinea, Va., in which 9 or more inches fell in less than 45 minutes (MONTHLY WEATHER REVIEW, 1906, Vol. 34, pp. 406–407, 2 figs.). W. J. Humphreys elaborated on the explanation of a cloudburst outlined by Dr. Brooks (see above). "Could hail have occurred?" asked Mr. Kadel. C. F. Talman called attention to the fact that hail is known in the tropics, especially in India, and that it had been reported in the mountains of Haiti and in Jamaica. Dr. Brooks called attention to the fact that most of the Indian hail occurred in the arid and semiarid parts of subtropical northwestern India, and after raising the question as to whether the Jamaica hail was not in the mountains, stated that it appeared extremely unlikely that hail would ever fall at sea level in Panama. [*Note:* An article by H. G. Cornthwaite, on "Panama thunderstorms" (MONTHLY WEATHER REVIEW, Oct., 1919, Vol. 47, pp. 722–724) mentions the occurrence of hail in the Canal Zone on three occasions in 12 years.] Mr. Kadel said that where such intense rainfalls occur, the gages should have greater capacity in the tipping bucket.

[2] Reprinted from *Bull. Amer. Met'l Soc.* May, 1920, vol. 1, no. 5, p. 52.

SUNSHINE AND CLOUDINESS IN THE CANAL ZONE.

By H. G. CORNTHWAITE, Assistant Chief Hydrographer.

[Balboa Heights, C. Z., Apr. 21, 1920.]

The degree of daytime cloudiness in the Canal Zone is less during the dry season than in the rainy season, but even in the dry season the sky is by no means cloudless, the average degree of daytime cloudiness being about 50 per cent of the sky obscured in the dry season and about 75 per cent of the sky obscured in the rainy season. There is not the intense unobstructed solar radiation in the Canal Zone that is experienced in dry sections of the United States. The cloudless skies so common in the semiarid sections of southwestern United States are practically unknown in the Canal Zone.

March is generally the month of minimum cloudiness in the Canal Zone, while June and November are usually the months of maximum cloudiness and least sunshine. The maximum *duration* of sunshine occurs during the dry season, usually in January, and the maximum *intensity* occurs in March or April.

The daytime cloudiness is somewhat greater in the interior and over the Pacific section than on the Atlantic side. The prevailing winds during the greater part of the year blow from off the Atlantic. These winds reach the isthmus with water vapor mostly uncondensed, and therefore not visible as clouds. In crossing in the Isthmus a large part of the water vapor carried by these winds is condensed and becomes visible as cloud, the most effective agents of condensation being the ascending air currents that develop over the excessively heated land surface and the upward deflection of the winds approaching and passing over the Continental Divide. Any increase in elevation of a mass of air, from whatever cause, results in a corresponding decrease in its temperature. When the temperature of the ascending air current has been lowered to the dew point, its invisible water vapor condenses and becomes visible as cloud.

Night cloudiness—No actual records are available of nighttime cloudiness, but in general the cloudiness is much greater during the daytime than at night. This is especially noticeable during the dry season, when heavy cumulus clouds form regularly during the daytime, and as regularly disappear with the approach of night.

Over the interior night cloudiness often takes the form of fogs, which are numerous during the rainy season, but which usually lift or dissipate before 8.30 a. m. Few fogs occur along either coast in the vicinity of the Canal Zone. (See fig. 2.)

During the rainy season night and early morning cloudiness is heavier along the Atlantic coast, where approximately half of the total rainfall occurs during the nighttime.

Monthly extremes.—The maximum monthly daytime cloudiness recorded during any one month of the past 12 years was 93 per cent at Colon in July, 1914, and the least average monthly cloudiness was 30 per cent at Balboa Heights in February, 1918.

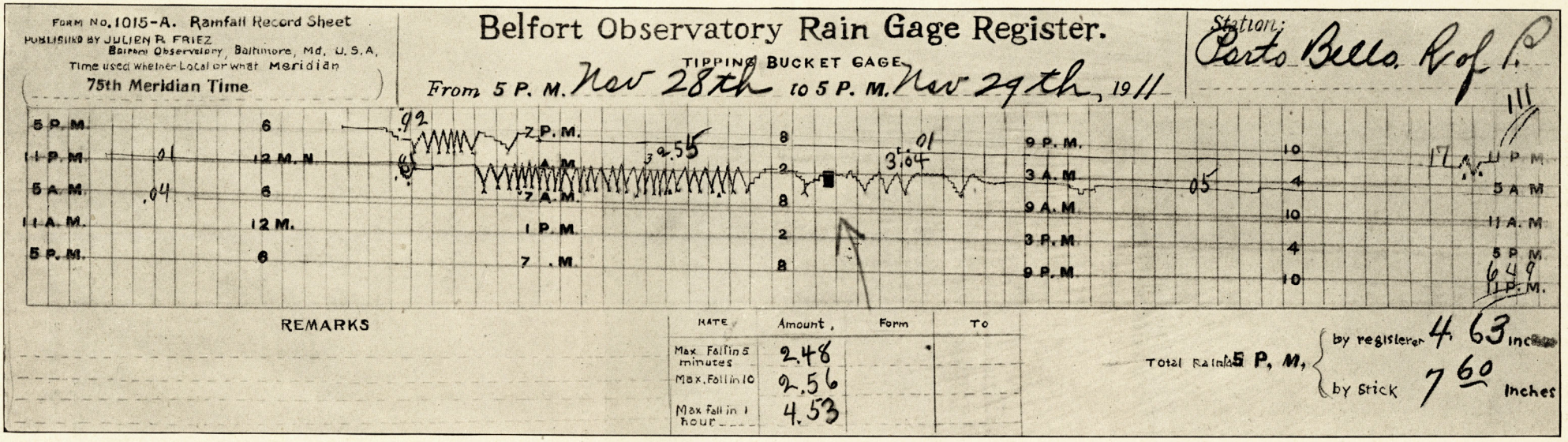


FIG. 1.—Retouched photostat of rainfall record showing what is believed to have been a downpour of 2.47 inches in three minutes—the most intense rainfall on record.

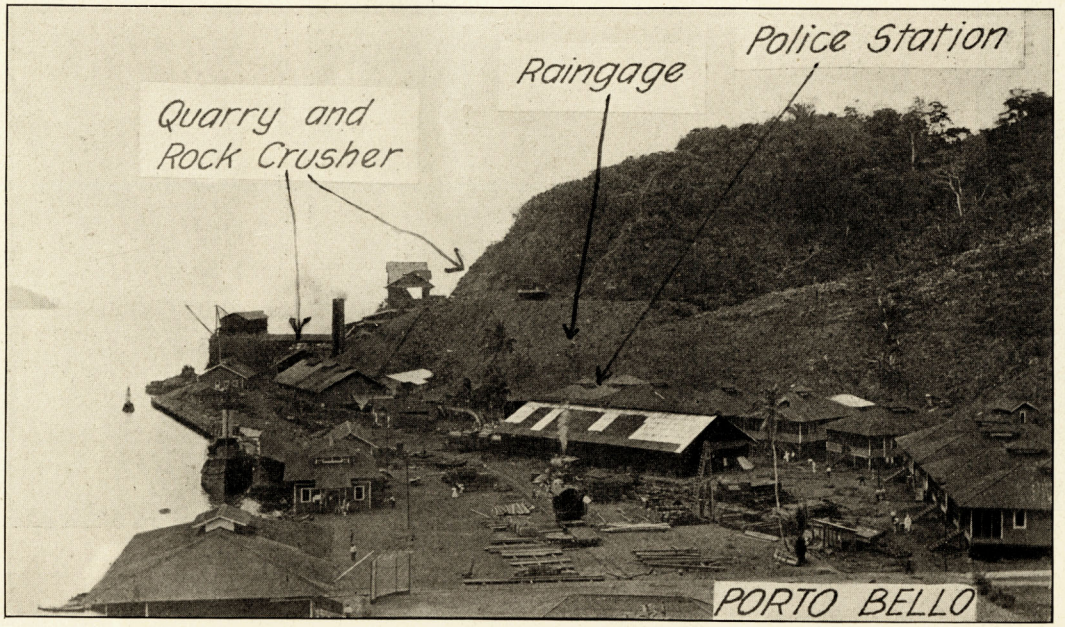
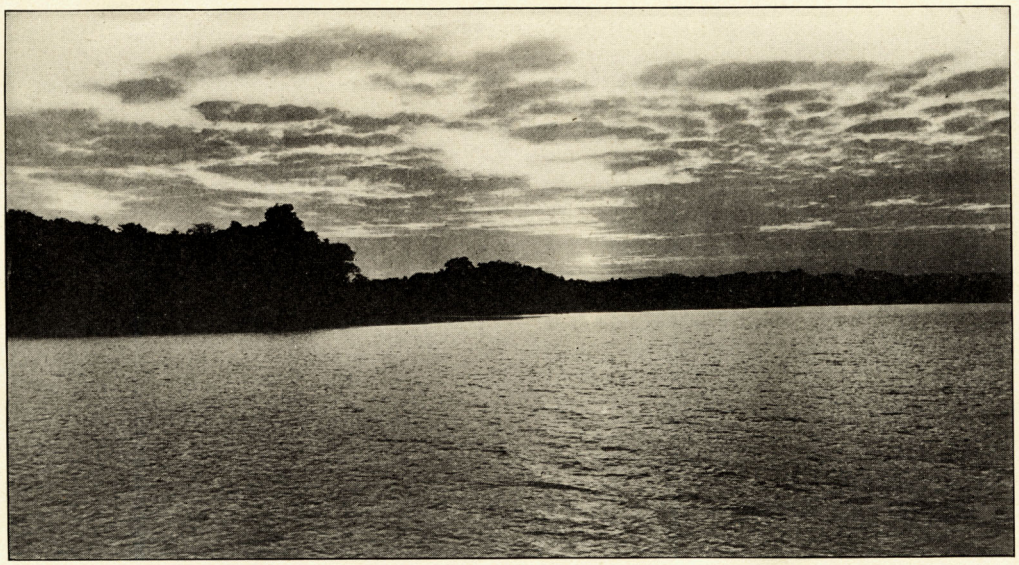


FIG. 2.—Porto Bello, Canal Zone.

[To face p. 276.]



Sunrise on the Pearl Islands in Panama Bay. Showing A. Cu. and St. Cu. clouds.

Heavy cumulus clouds verging on the St. Cu. type banked low near the Pacific entrance of the canal.

Early morning fog over the Panama Canal at Culebra where the canal cuts through the Continental Divide.

[Photos by H. G. Cornthwaite.]

The maximum duration of sunshine recorded during any one month was 89 per cent of possible at Balboa Heights in January, 1915, and the least duration of sunshine for any month was 15 per cent at Balboa Heights in May, 1913.

Prevailing cloud types.—The cumulus form of lower clouds are most numerous during the dry season and the strato-cumulus, stratus, and nimbus forms during the rainy season. All of the common types of upper clouds are well represented throughout the year, but in the rainy season they are frequently obscured by the lower clouds.

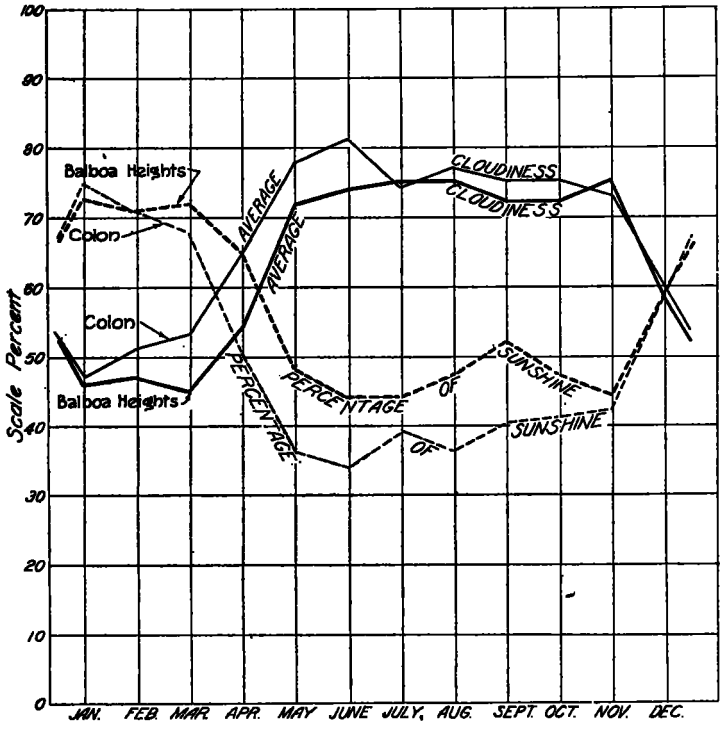


FIG. 1.—Average monthly conditions of cloudiness and sunshine in the Canal Zone.

Comparisons.—Compared with conditions in many sections of the United States, cloudiness in the Canal Zone is relatively heavy, especially during the rainy season; but prevailing rainstorms usually are of short duration, followed by clearing weather and sunshine and the cloudiness is so broken and intermittent that there are very few days with *no sunshine*. But when general storms visit the Isthmus (such as "Northers") there may be periods of two or three consecutive days with the sun entirely obscured.

The average number of days *without sunshine* during the past 12 years has been about 12 per year on the Pacific side and 10 on the Atlantic side. The longest consecutive period of authentic record in the Canal Zone without sunshine is about four days.[1]

The average number of clear days per year has been 36 at Balboa Heights and 54 at Colon; partly cloudy days 172 at Balboa Heights and 166 at Colon; and cloudy days, 157 at Balboa Heights and 145 at Colon. A clear day being one with average cloudiness of three-tenths or less; partly cloudy, from four-tenths to seven-tenths; and cloudy, eight-tenths or more.

The attached table and diagram show average monthly conditions of cloudiness and sunshine in the Canal Zone.

Average monthly cloudiness and percentage of possible sunshine—Canal Zone.

	Cloudiness—per cent of sky obscured.[a]			Sunshine—per cent of possible.[c]	
	Balboa Heights, Pacific coast (13 years).	Culebra, interior (7 years).[b]	Colon, Atlantic coast (11 years).	Balboa Heights, Pacific coast (12 years).	Colon, Atlantic coast (12 years).
January	47	49	46	75	73
February	51	50	47	71	71
March	53	47	45	68	72
April	65	63	54	50	65
May	78	77	72	36	48
June	81	81	74	34	44
July	74	80	75	39	44
August	77	78	75	36	47
September	75	77	72	40	52
October	75	79	72	41	47
November	73	80	75	42	44
December	60	61	58	59	59
Year	67	68	64	49	56
Dry season	54	52	48	66	70
Rainy season	74	77	72	41	48

[1] Based on records from automatic electric sunshine recorders. These records are not always absolutely accurate, being subject to errors due to improper adjustment of instrument, lagging, etc., but they are considered the best available.

[a] Cloudiness records are from bi-hourly eye observations.

[b] Station closed in 1914.

[c] Sunshine records are from automatic electric sunshine recorders, expressed in percentage of possible. In the Tropics possible sunshine, or the duration of daylight, varies but little from month to month, since there is little variation in the length of day and night throughout the year.

HUMIDITY AND HOT WEATHER.

By H. G. CORNTHWAITE, Acting Chief Hydrographer.

[Balboa Heights, Canal Zone, Mar. 15, 1920.]

In a general way it is well known that conditions of humidity and wind movement are important factors in ameliorating or aggravating the depressing effects of hot weather. The maximum temperature recorded is therefore not an adequate measure of the temperature actually felt by the human body. For example, a temperature of 90° F. with high humidity and no wind seems very hot and oppressive, while the same temperature with a low degree of humidity and a fresh breeze seems relatively cool and refreshing.

For want of a better term the temperature actually felt by the human body may be called the *sensible* temperature. The reading of the wet bulb thermometer is not an exact measure of the sensible temperature, but it is the best measure available, as it represents the temperature of a moist body exposed to the breeze in process of cooling through the agency of evaporation.

The effects of humidity and wind movement on the *sensible* temperature may be explained as follows:

With a high degree of humidity the air is nearly saturated with invisible vapor, and its capacity for taking up additional moisture is small; consequently, the rate of evaporation is slow and the evaporating surface is cooled but slightly.

With a low degree of humidity the capacity of the air for taking up additional moisture is large, which favors a rapid rate of evaporation and extensive cooling of the evaporating surface.

Increased wind movement induces a more rapid rate of evaporation, with a resulting increase in its cooling effect, and also tends to cool the body by the removal of heat by conduction and convection.

Also, it is probable that high humidity has a depressing physiological effect upon the human body that is not